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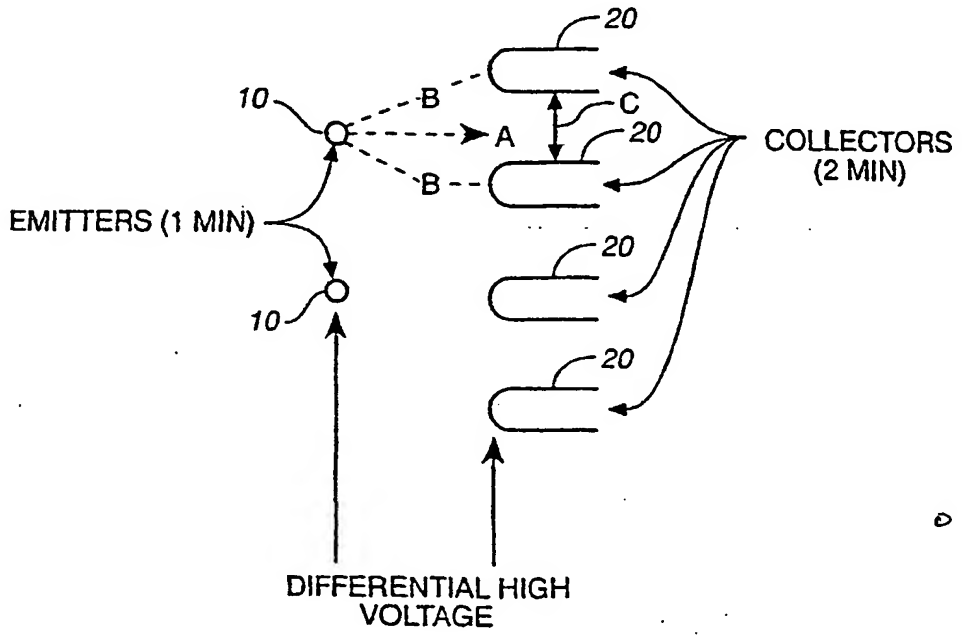
Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND APPARATUS TO REDUCE OZONE PRODUCTION IN ION WIND DEVICES



(57) Abstract: A method to limit ozone production in wind ion devices while simultaneously realizing incidents of high acceleration in such devices varies the high voltage potential across the array of emitter(s) (10) and collectors (20) over time in such a manner as to generate a wave effect of airflow. The variance may be achieved by switching, ramping, or gating the high voltage potential delivered to the array.

WO 01/47803 A1

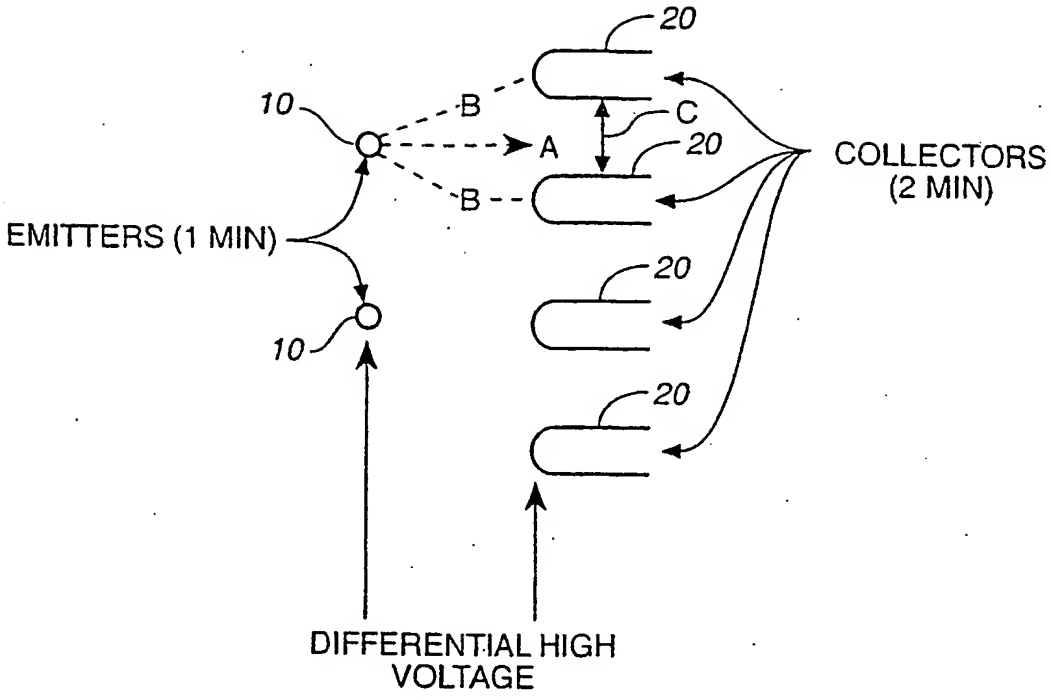

20
10
B
C
A
20
B
COLLECTORS
(2 MIN)
EMITTERS (1 MIN)
20
10
20
DIFFERENTIAL HIGH
VOLTAGE

FIG._1

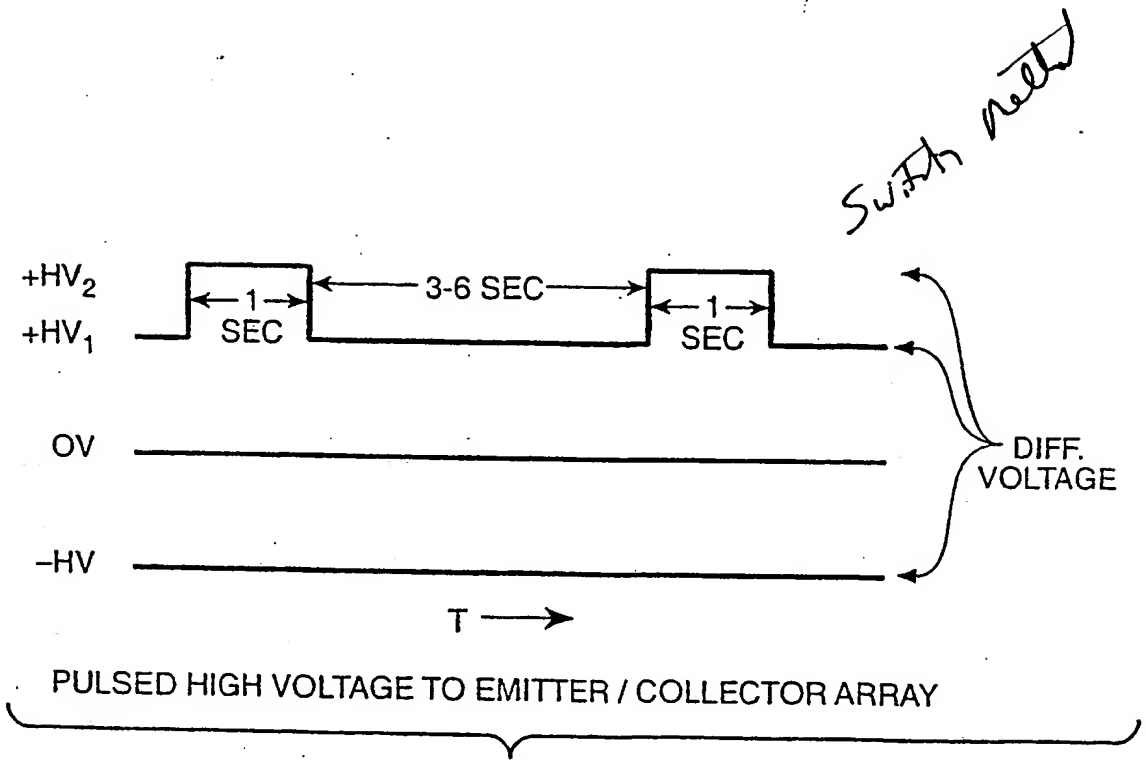

Switch mode
+HV2
+HV1
1
SEC
3-6 SEC
1
SEC
OV
DIFF.
VOLTAGE
-HV
T
PULSED HIGH VOLTAGE TO EMITTER / COLLECTOR ARRAY

FIG._2

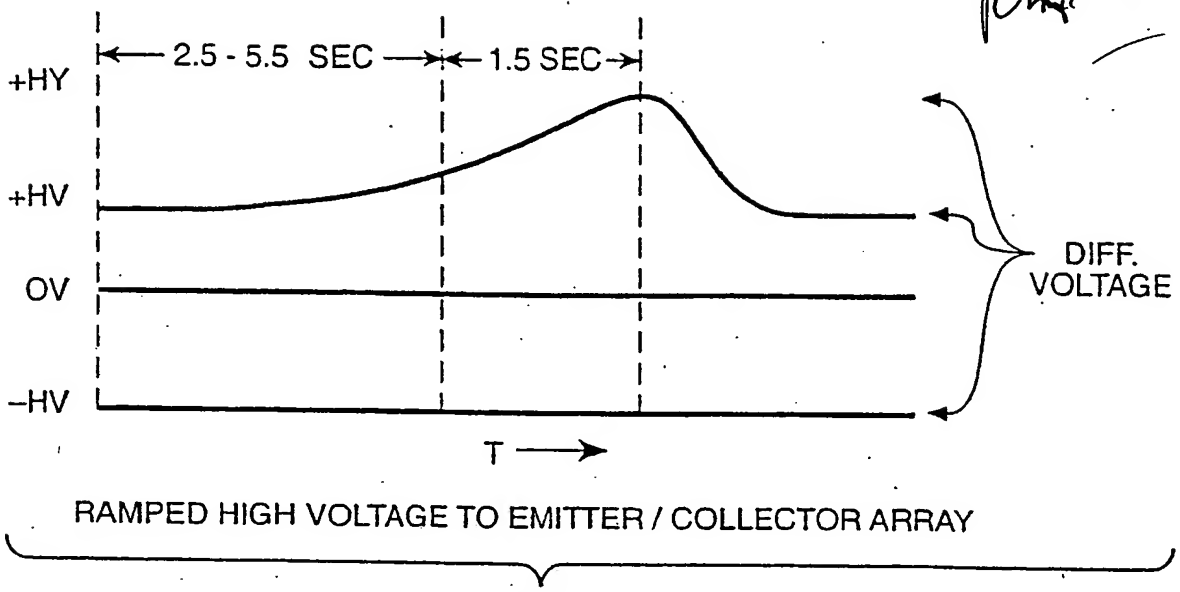

2.5 - 5.5 SEC
1.5 SEC
+HY
+HV
OV
–HV
T
DIFF. VOLTAGE
RAMPED HIGH VOLTAGE TO EMITTER / COLLECTOR ARRAY

FIG._3

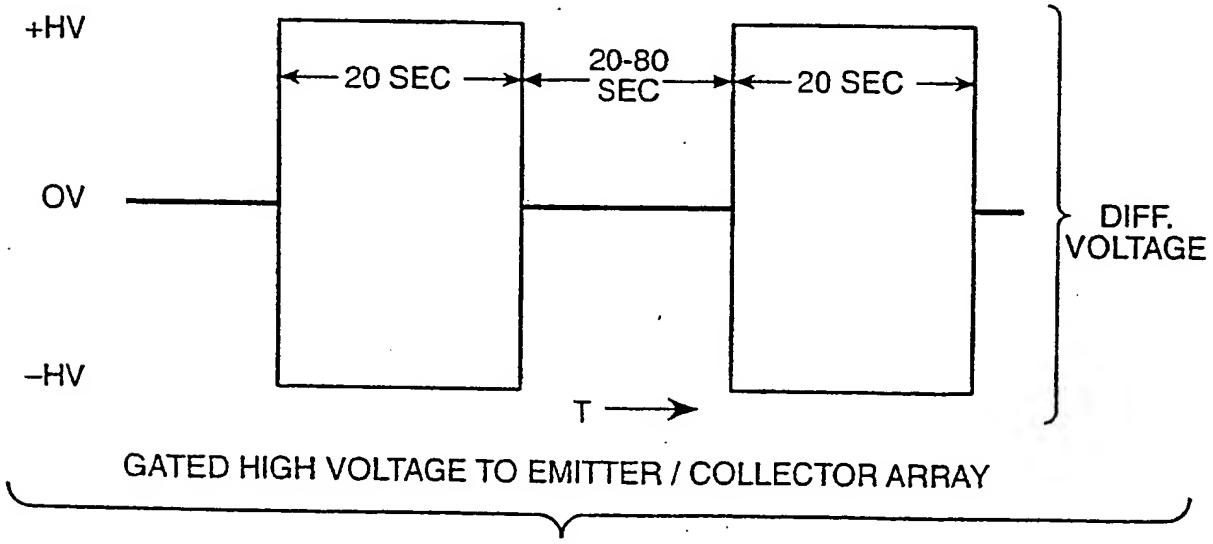

+HV
OV
–HV
20 SEC
20-80 SEC
20 SEC
T
DIFF. VOLTAGE
GATED HIGH VOLTAGE TO EMITTER / COLLECTOR ARRAY

FIG._4

METHOD AND APPARATUS TO REDUCE OZONE PRODUCTION IN ION WIND DEVICES

BACKGROUND OF THE INVENTION

Technical Field

This invention relates generally to ion generators and ion wind devices, and more specifically to an improved method and apparatus for reducing the production of ozone in ion wind devices.

Background Art

Ion wind devices such as described in Lee U.S. Patent No. 4,789,801 (incorporated herein by reference) provide accelerated gas ions generated by the use of differential high voltage electric fields between an array of one or more emitters and a plurality of collectors (accelerators). The ions are entrained in the ambient bulk gases, causing the gases to flow. Gas velocities can reach as high as eight hundred feet per minute. However, the high voltage electric fields used to generate the gas ions and provide the force necessary for gas acceleration are also responsible for creating molecular dissociation reactions, the most common of which include ozone generated from oxygen when such devices are operating in a breathable atmosphere. It is an object of this invention to provide methods to reduce the production of ozone in such devices.

The U.S. Food and Drug Administration has determined that indoor airborne ozone in concentrations above 50 ppb (parts per billion) may be hazardous to humans. NIOSH has ruled that indoor concentrations of ozone above 100 ppb may be hazardous to humans. Devices which utilize high voltage electric fields to generate atmospheric plasma, corona discharge and air ions are all susceptible to generating the allotrope, ozone. There exists a linear relationship between the level of the high voltage fields and current and the level of ozone concentration in most direct current operated ion wind systems. Also, a linear relationship exists between the acceleration velocity and intensity of the electric fields. Typically the higher the voltage the higher the acceleration. Since it is desired to have maximum acceleration, methods must be employed to limit or eliminate unwanted ozone

production.

Disclosure of Invention

Ion wind devices accelerate gas ions by applying differential high voltage electric fields between one or more emitters and a plurality of collectors (accelerators). The inventive method limits ozone production while simultaneously realizing incidents of high acceleration in such devices by varying the high voltage potential across the array of emitter(s) and collectors over time in such a manner as to generate a "wave effect" of airflow. Several alternative methods of varying the high voltage potential have proven successful in accomplishing this wave effect. One method, which may be referred to as a switching method, allows the positive emitter high voltage potential to operate at a reduced level (e.g., + 6 KV) for a period of time (e.g., three seconds), and then switch to a higher potential (e.g., +8.5 KV) for another, and preferably shorter period of time (e.g., one second). The result is that at the lower (less ozone generating level) airflow is simultaneously reduced. However, when switched from the lower to the higher potential for one second higher airflow is momentarily achieved due to accelerated ion momentum. The overall average airflow is slightly higher than the linear three to time ratio due to ion momentum transfer and resulting inertia from it.

An alternative method, which may be referred to as a ramping method, accomplishes the wave effect by use of an electronic circuit to generate a nonlinear sawtooth ramp driving voltage. Typical ramp duration would also be, e.g., four seconds, with the ending portion and trailing edge effecting the highest voltage state for approximately one second. In both the switching method and ramping method airflow velocities were varied typically from a low state of 300 feet per minute to a high state of 500 feet per minute. Subsequent ozone production levels varied from a low of 17ppb for 3 seconds to a high of 50ppb for less than one second. Overall average ozone production was less than 25 ppb. This represents an improvement over operating the same array at a steady state of 350 feet per minute and generating an average of 35 ppb ozone. Furthermore, the burst of 500 feet per minute of airflow improves perceptible operation of the ion wind device.

A further alternate method which also produces the wave effect may be referred to as a gate method, which is a gate voltage which switches either (or both) the positive high voltage to the emitter or the negative high voltage to the collector at timed intervals, such as

20 seconds off and then 20 seconds at the high voltage state. Finally, either the switching method, the ramping method or the gate method may be used in concert with each other or with other ozone control.

Brief Description of the Drawings

Fig. 1 is a schematic view of an emitter and collector (accelerator) array of an ion wind device;

Fig. 2 is a schematic view of the switching method of varying the high voltage potential between the emitter(s) and collectors of this invention;

Fig. 3 is a schematic view of the ramping method of this invention; and

Fig. 4 is a schematic view of the gate method of this invention.

Best Mode for Carrying Out the Invention

Fig. 1 refers to a typical ion wind array such as described in Lee U.S. Patent No. 4,789,801. The emitter or emitters 10 are typically constructed of .1 mm pure tungsten wire and may be of any length. The collectors (sometimes referred to as accelerators) 20 are typically constructed of any non corrosive conductive material such as copper, aluminum, stainless steel, or brass. The emitter 10 is always located opposite and at the center (A) of the opening of the collectors 20. The equidistant (B) of the emitter 10 to the leading edge (radius) of the collector 20 may vary depending upon desired operational effect, but is typically one inch. This is also true of the spacing (C) between the collectors 20.

The differential voltage applied across the emitter/collector array must be at least 6,500 volts in order to effect any substantial ion mobility and subsequent airflow. Typical configurations consist of applying a positive high voltage to the emitter 10 and a negative high voltage to the collector 20 to achieve a maximum differential voltage of 15,000 volts D.C. These voltage potentials may be reversed, however, when this is done an uneven plasma envelope is developed at the emitter source, which results in excessive corona noise and ozone production. Alternatively, the array may be driven by a single positive or single negative high voltage excitation source to the emitter 10 with the collectors 20 having a high impedance return to ground (to reduce load current and breakover arcing). Also, the excitation voltage may be modulated in ways taught U.S. Patent No. 4,789,801 to achieve desired results.

Fig. 2 is a schematic view of the switching method of this invention. This method provides a pulsed high voltage to the emitter/collector array, i.e., a high voltage excitation configuration to drive the array by switching from a lower-level positive high voltage state HV1 to a higher-level positive high voltage state HV2 at pre-determined time intervals, e.g., one second HV1 and three seconds HV2. It is not necessary to include the negative voltage reference -HV if the positive voltage is increased proportionally to achieve like airflow levels. Also, the voltage polarities may be reversed with minimal effect upon the airflow levels.

Fig. 3 is a schematic view of the ramping method of this invention. This method provides a ramped high voltage to the emitter/collector array, i.e., a high voltage excitation configuration to drive the array with a voltage ramp, which changes in amplitude over a variable time interval. The low-level high voltage on time state may typically be as long as 5.5 seconds for minimal ozone production. Conversely, the low-level high voltage may be as short as 2.5 seconds for maximum desired ozone. The ramp up time is typically 1.5 seconds to create a differential voltage in excess of 14,000 volts. Actual time and amplitude may be varied for effect depending upon desired airflow and ozone levels.

Fig. 4 is a schematic view of the gate method of this invention. This method provides a sequential high voltage to the emitter/collector array, i.e., a high voltage gating (or switching on/off) method whereby the differential high voltage applied to the array is turned from a zero state to a maximum high state at pre-determined intervals. The on/off timed states and differential amplitude may be varied for effect. For example, a 20-second on to 20 second off time and a differential high voltage level of 15,000 volts would be the maximum duty cycle and amplitude for airflow and ozone output. As in the switching and ramping methods, supra, it is not absolutely necessary to use a negative high voltage on the collector array if the voltage level is increased proportionally on the emitter array, since the airflow and ozone levels will change proportionally in like ambient conditions. However, a negative voltage applied to the collector array is usually used to improve contaminant collection, limit circuit cost and minimize corona arcing to neutral components located in the vicinity of the array housing.

CLAIMS

What is claimed as invention is:

1. A method of reducing ozone production in ion wind devices, said method comprising the steps of:

providing an emitter;

providing a plurality of collectors;

positioning said collectors generally equidistant from said emitter to form an array;

providing a high voltage potential between said emitter and said collectors; and

varying said high voltage potential over time to generate a wave effect of airflow and reduce total ozone production.

2. The method of reducing ozone production in ion wind devices of claim 1 wherein said step of varying said high voltage potential over time comprises switching said high voltage potential from a lower high voltage level for a first period of time, to a higher high voltage potential for a second period of time.

3. The method of reducing ozone production in ion wind devices of claim 2 wherein said lower high voltage level is approximately +6 KV, and said higher high voltage potential is approximately +8.5 KV.

4. The method of reducing ozone production in ion wind devices of claim 2 wherein said first period of time is greater than said second period of time.

5. The method of reducing ozone production in ion wind devices of claim 4 wherein said first period of time is approximately 3 seconds, and said second period of time is approximately 1 second.

6. The method of reducing ozone production in ion wind devices of claim 1 wherein said step of varying said high voltage potential over time comprises providing a nonlinear ramp driving voltage to said emitter/collector array.

7. The method of reducing ozone production in ion wind devices of claim 6 wherein said nonlinear ramp driving voltage has a duration of approximately 4 seconds.

8. The method of reducing ozone production in ion wind devices of claim 6 wherein said nonlinear ramp driving voltage has an ending portion and trailing edge effecting the highest voltage state for approximately 1 second.

9. The method of reducing ozone production in ion wind devices of claim 1 wherein said step of varying said high voltage potential over time comprises providing a gating voltage to said emitter/collector array.

10. The method of reducing ozone production in ion wind devices of claim 9 wherein said gating voltage is turned from a zero state to a maximum high state at predetermined time intervals.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/35401

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : C01B 13/10; B01J 19/08; H01T 23/00; F02M 27/00; A45D 19/16

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,E	US 6,176,977 B1 (TAYLOR et al) 23 January 2001, (23/01/01) entire document.	1-10
Y,E	US 6,812,671 B1 (TAYLOR et al) 06 February 2001 (06/02/01) entire document.	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 MARCH 2001	13 APR 2001

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	CHUC TRAN
Facsimile No. (703) 305-3230	Telephone No. (703) 306-5984

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US00/35401

A. CLASSIFICATION OF SUBJECT MATTER:
US CL. :

132/116, 154, 272, 112, 116, 148, 152, 271. 272; 204/176; 422/186.07; 361/226, 230, 232; 123/539, 272; 15/104.002, 246.3, 344, 345, 39.5, 40

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

132/116, 154, 272, 112, 116, 148, 152, 271. 272; 204/176; 422/186.07; 361/226, 230, 232; 123/539, 272; 15/104.002, 246.3, 344, 345, 39.5, 40

JOHNSON & STAINBROOK, LLP

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Fax: (707) 578-3133

Reply to Santa Rosa

October 12, 2001

ATTORNEY-CLIENT PRIVILEGED COMMUNICATION

This communication is protected by the attorney-client privilege and should be treated in a confidential manner. Any disclosure to other than key management personnel on a need-to-know basis may jeopardize the privilege and require disclosure to adverse parties in litigation.

Jim Lee
Zenion Industries, Inc.
5430 Commerce Blvd.
Rohnert Park, CA 94928

Re: PCT Patent Application
TITLE: METHOD AND APPARATUS TO REDUCE OZONE PRODUCTION IN ION WIND DEVICES
International Application Number PCT/US00/35401
International Preliminary Examination Written Opinion
Our Reference No. 00096.P2

Dear Jim:

We have received a communication from the International Preliminary Examining Authority concerning the above-indicated PCT application. A copy of the Written Opinion and the references it cites are enclosed.

You may not have gone through this exercise before, and this communication may prove to be somewhat confusing. Accordingly, it is my hope to set out a straightforward summary of the Written Opinion and how you may wish to treat it.

Summary of Opinion

The Examining Authority has proffered the opinion that the invention claimed in Claim

Nos. 1 through 10 of your application are both novel and involve an inventive step, i.e., are nonobvious (see page 3 of the report). This is a highly favorable opinion and suggests that the Examiner would likely grant you a patent on this application in the United States. It may be treated quite differently in other countries, as other examiners are not bound by this opinion. Nonetheless, there is considerable justification for optimism at this point.

In short order we shall be mailing you a notice regarding the deadlines for making national filings based on this PCT application. Beforehand, however, please call me if you have any questions, please feel free to call at any time.

I look forward to speaking with you soon.

Very truly yours,

JOHNSON & STAINBROOK, LLP

Craig M. Stainbrook

CMS/bc
enclosures

FLIESLER DUBB MEYER & LOVEJOY LLP

NEW MATTER FILE MEMO

(Use to open new matter. All information must be included.)

Date 10 / 26 / 2001

Client Name SHARPER IMAGE CORPORATION

Matter No. Client Code SHPR File No. 1327 Country WO Sequence No. 0

File Title METHOD AND APPARATUS TO REDUCE OZONE PRODUCTION IN ION WIND DEVICES

OMEGA MATTER INFORMATION

Billing Atty SRM

Responsible Atty SRM

Type of Law PAT

Type of Client LGENT

Office 1

Technology CON

Country Source of Income US

Location SRM:NTH

PCMASTER MATTER INFORMATION

Case Type REGULAR

Relation Type (patents only) ORIGINAL

Filing Type PCT

Related File(s) if any

Status G

Sub Status P

OMEGA USER INFORMATION

Client Code SHPR Div

File Type PCT File 1327

SFX WO S# 0

CC1/CC2/CC3

FSFX FS#

Client Reference

Prior Reference

Product Description

Contact

Division Name

Adm Fee % 5.0

OMEGA BILLING INFORMATION (Defaults)

Rate Schedule 1-Standard Rate
Print Draft in M
Billing Group C1
Bill Format 3339
Rebill Format 50 - *Standard Rate
Store all WIP X

Create Physical File? ✔ 3-way Folder ____ Redwell ____ Other (Specify: ____) ____ None

Remarks

Return File to JAN

NEW MATTER FILE MEMO RESPONSIBILITIES

Secretary: Complete memo; Open pending new matter in Omega; Deliver cc's
Records File Clerk: Verify accuracy of pending new matter; Perform conflict check as required; Activate matter; Create physical file
Docket: Open matter in PCMaster; Docket action; Return stamped copy of memo to secretary

cc: Billing Partner, Records File Clerk, Billing Clerk, Docket (and Litigation Docket and Litigation File Clerk for Litigation file types)

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

To:
JOHNSON, Larry, D.
Johnson & Stainbrook, LLP
Suite 203
3550 Round Barn Boulevard
Santa Rosa, CA 95403
ETATS-UNIS D'AMERIQUE

Date of mailing (day/month/year) 05 July 2001 (05.07.01)		
Applicant's or agent's file reference 00096.P2	IMPORTANT NOTICE	
International application No. PCT/US00/35401	International filing date (day/month/year) 22 December 2000 (22.12.00)	Priority date (day/month/year) 24 December 1999 (24.12.99)
Applicant LEE, Jim, L.		

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
   AU,KP,KR,US

   In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
   AE,AG,AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,BZ,CA,CH,CN,CR,CU,CZ,DE,DK,DM,DZ,EA,EE,EP,ES,
   FI,GB,GD,GE,GH,GM,HR,HU,ID,IL,IN,IS,JP,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MA,MD,MG,MK,
   MN,MW,MX,MZ,NO,NZ,OA,PL,PT,RO,RU,SD,SE,SG,SI,SK,SL,TJ,TM,TR,TT,TZ,UA,UG,UZ,VN,YU,

   The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
   05 July 2001 (05.07.01) under No. WO 01/47803

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

WAVE

JOHNSON & STAINBROOK, LLP

Registered Patent Attorneys
Patents, Trademarks, Copyrights
and Related Matters

1327WO$

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Fax: (707) 578-3133

Reply to Santa Rosa

18 July 2001

Jim Lee
Zenion Industries, Inc
5430 Commerce Blvd.
Rohnert Park, CA 94928

Re: TITLE: METHOD AND APPARATUS TO REDUCE OZONE PRODUCTION IN ION WIND DEVICES
International Application Number: PCT/US00/35401
Our Reference Number: 00096.P2

Dear Jim:

Please find enclosed a copy of your International Application as published on **July 5, 2001.** As anticipated, publication of your application was made at roughly month 18 from the priority date of **December 24, 1999.**

As you know, the Demand for Chapter II Examination has already been made. Accordingly, we anticipate receiving a Written Preliminary Opinion of patentability sometime withn the next six months.

Very truly yours,

JOHNSON & STAINBROOK, LP

Craig M. Stainbrook